SANDEE
South Asian Network for Development and Environmental Economics

POLICY Brief

Number 26-07, December 2007

The Economics of Arsenic Water Pollution – A Study from Bangladesh

Bangladesh is facing a major health crisis because arsenic is poisoning a large percentage of the country's drinking water. Although the government has taken a number of positive steps to address this challenge, much more work remains to be done as an estimated 28-50 million Bangladeshis are currently at risk from arsenic-contaminated water. To assess the economic case for dealing with this problem, a SANDEE study looks at the health impacts and costs associated with arsenic pollution and discusses the financial outlay needed to resolve the problem.

The study estimates that some 7 to 12 million person-days per year are lost as a result of arsenic exposure in Bangladesh. In addition, individuals who are sick spend between 207 (US$ 3.5) million to 369 (US$ 6.25) million taka per year for medical help. There are a number of relatively low-cost solutions to the arsenic contamination problem. Households would be willing to contribute towards the implementation of these solutions as these costs are lower than the expenditures already being made by those suffering from arsenic exposure. The study recommends that the government should support affected communities through financial assistance, education and awareness raising. This research is the work of M Zakir Hossain Khan, Economic Research Group (ERG), Bangladesh.

A SLOW POISON

Arsenic is a natural mineral that is present in the soil, however concentrations above 50 parts per billion (ppb) in drinking water are likely to create health problems. Unfortunately, studies show that nearly 30 percent of all tube wells in arsenic-affected areas of Bangladesh have a higher arsenic content than the recommended safe limit. For the country as a whole, this means that up to 60 percent of the population is at risk from arsenic exposure.

Bangladesh has been a frontrunner in South Asia in terms of providing access to safe drinking water. Over the years it has successfully contained water-borne diseases such as cholera. However, since the discovery of arsenic in ground water in the 1990's, the country has struggled to resolve this latest water pollution problem. The government has tried to inform people about the presence of arsenic in drinking water using a color coding system for tube wells. A green-colored tube-well is safe for collecting drinking and cooking water, while a red-colored one is not. Nonetheless, either due to limited alternative sources of water or for other reasons, many households continue to use water from the "unsafe" tube-wells.

ARSENICOSIS – A SLOW KILLER

Arsenicosis is primarily caused by drinking arsenic-contaminated water over a long period. It usually takes five to twenty years to develop. Because of its slow progress, the evolution of the disease is divided into several stages. In the primary stage, an Arsenicosis patient may develop several symptoms, sometimes simultaneously. These include blackening of some parts of the body or the whole body (Melanosis); thickening and roughness of the palms and soles (Keratosis); redness of the conjunctiva (Conjunctivitis); inflammation of the respiratory tract; and nausea and vomiting (Gastroenteritis).

(This policy brief is based on SANDEE working paper No. 27-07, 'Managing The Arsenic Disaster in Water Supply: Risk Measurement, Costs of Illness and Policy Choices for Bangladesh' by M Zakir Hossain Khan, Economic Research Group Dhaka, Bangladesh. The full report is available at www.sandeeonline.org)

If a patient continues to be exposed to arsenic-contaminated water, and if adequate preventive measures are not adopted, then the symptoms advance and become more visible. Symptoms in this secondary stage include white intermittent dots within blackened areas (called Leukonelanosis or Rain Drop Syndrome), nodular growth on the palms and soles (Hyper-Keratosis), swelling of the feet and legs (Non-pitting edema), and peripheral neuropathy as well as liver and kidney disorders. In the tertiary stage, an Arsenicosis patient's physical condition deteriorates rapidly and the condition becomes irreversible. Gangrene, cancer of the skin, lungs and urinary bladder and kidney and liver failure can occur at this stage.

The way in which Arsenicosis affects people varies significantly depending on an individual's exposure to arsenic and their socio-economic circumstances. Since arsenic is a bio-accumulative element, the probability of *Arsenicosis* increases with age (up to fifty-five years) for both men and women. Men in Bangladesh have a lower probability of getting sick than women. This is probably due to the poor health status of women in many poor households and also due to the fact that men often get more nutritious food than women.

THE COST OF ARSENIC POLLUTION

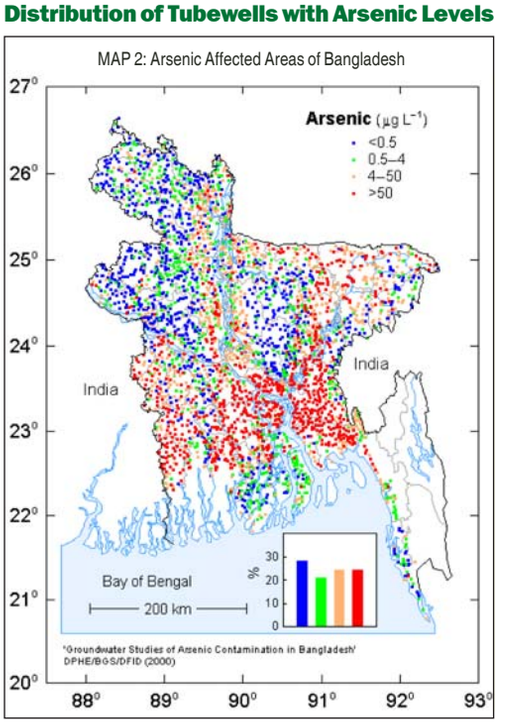
Many people in Bangladesh already suffer from illnesses linked to arsenic poisoning. For example, according to one estimate, there are some 38,380 Arsenicosis or other arsenic-affected patients in Bangladesh. Arsenicosis is poisoning caused by long-term exposure to low levels of arsenic. It has many symptoms and side effects and can lead to death through multiple organ failure. Khan takes two main factors into account to estimate how much arsenic poisoning costs households: the amount of money they have to spend because they get sick due to the contamination of their drinking water; and how much it costs them to avoid arsenic poisoning. These costs include the wages lost due to sick days and the medical costs linked to arsenic-related sicknesses. To get an overall assessment of the impact of arsenic contamination on the population of Bangladesh as a whole, Khan also investigates the likelihood of an individual becoming ill as a result of being exposed to arsenic-contamination. The impact of factors such as education and awareness-raising on people's health are also assessed.

THE STUDY SITE

To estimate the cost of arsenic-related illness and to get other information necessary for the study, 5563 individuals from 878 households were surveyed in 2005. These people live in two sub-districts, Matlab and Laksman. These areas are located in the southeastern part of Bangladesh, which is the most arsenic-prone region in Bangladesh. Only 24 percent of tube-wells in Matlab and 32 percent of tube-wells in Laksman are labeled safe (green). However, 56 percent of households still drink water from red-labeled (i.e. unsafe) tube wells. Since all the tube wells in the study area are not color coded, it is possible that 86 percent of the households, who drink water from shallow aquifer sources, may actually be exposed to arsenic.

The two sub-districts are very similar in terms of levels of arsenic-related illnesses. About 5 percent of all the people surveyed have at least one of the various types of Arsenicosis: 4 percent have black spots or Melanosis, 3 percent have thickening or roughness of palms and soles (Keratosis), 2 percent have redness in their eyes or Conjunctivitis, 2 percent have inflammation of the respiratory tract, 0.43 percent have swelling of the feet and legs, and 0.068 percent suffer from liver and kidney failure.

Distribution of Tubewells with Arsenic Levels



THE COSTS OF POLLUTION AND THE BENEFITS OF CLEAN-UP

Despite these health problems, affected households do not spend much money for avoiding arsenic poisoning or mitigating its effects. Out of the sample of 5563 people, only 88 reported medical expenditure related to arsenic, while the average number of sick days lost to illnesses relating to arsenic poisoning was only 5.29 per person per year. Only 196 households (out of 878 households in the sample) used any form of equipment to avoid arsenic poisoning. These results can be explained by the fact that people in the survey area are generally very poor and therefore cannot afford to take days off work, seek medical assistance or invest in equipment that will protect them from contracting arsenic poisoning.

Overall, the mean cost of arsenic-related illness for an individual is US$ 2.89 per annum. This figure includes lost income and the expense of any medical measures. This is equivalent to 1057 Taka or US$ 17.91 per household per year and gives a measure of the amount of money households might be willing to pay to switch from an unsafe ("red") source of water to a safe ("green") supply. As people affected by arsenic poisoning cannot afford to take much time off work due to illness, and because they earn relatively low wages, the financial benefits they get from switching to safe water are relatively small (of course, they do gain significant health benefits).

THE NATIONAL PICTURE

Although on an individual level the economic impact of arsenic poisoning may seem relatively small, when the country-wide picture is assessed, it is clear that the cost of arsenic poisoning is significant. As mentioned, an estimated 28-50 million Bangladeshis are at risk from arsenic-contaminated water. Taking into consideration the likelihood of someone exposed to arsenic poisoning actually contracting an arsenic-related disease, it is possible to work out what the health and economic impact of this is. Even if the lowest figure of 28 million people is used, arsenic contamination causes 6.92 million workdays to be lost per year. It also causes a US$5.9 million loss in income for affected individuals. In addition, people who are affected spend in total between US$3.5 million to US$6.25 million per year on medical help. This means that, if it is possible to solve the arsenic contamination problem, then Bangladesh as a whole will benefit financially by between US$9.44 million and US$16.85 million per year.

While the economic benefits of solving Bangladesh's arsenic pollution challenge are clear, the cost of this work must be assessed. Currently, there are two main types of arsenic mitigation options available in Bangladesh. The first involves community-based mitigation techniques such as arsenic and iron removal plants, pond sand filters, deep tube wells and piped water supplies. These mitigation options require the involvement of institutions such as NGOs and Government agencies. Such agencies have to bear the initial investment costs, which can range from $2,000 to $240,000 for 100 households. Mitigation can also be undertaken at the household level using various

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This policy brief is an output of a research project funded by SANDEE. The view's expressed here are not necessarily those of SANDEE's sponsors.

Individual Information on Surveyed Households

Individual Level Information	Mean Comments	SD	N = 5563
Age	27.49	20.251	Years
Gender	50.40	percent	Male
Education	5.17	4.150	Years
Percent mitigating	12.21		Percent
Sick days (non working days [WDL])	5.29	2.016	Days per year
Melanosis (incidence)	3.52		Percent
Keratosis (incidence)	2.77		Percent
Conjunctivitis (incidence)	1.76		Percent
Inflammation of RT (incidence)	1.87		Percent
Hypo-pigmentation (incidence)	2.88		Percent
Hyper Keratosis (incidence)	1.10		Percent
Non-pitting *Edema* (incidence)	0.43		Percent
Liver and Kidney failure (incidence)	0.068		Percent

Source: Survey 2005

techniques such as the 'three-pitcher' method and the use of Shapla or Sono filters. These options cost between $4 to $4250 (initial capital) plus $0.5 to $25 annually for operation and maintenance.

THE WAY FORWARD

As already mentioned, households are willing to pay about US$18 a year to avoid arsenic poisoning. This means that they would probably be willing to invest in one of the lower priced household-level mitigation methods. This would be even more likely to occur if initial costs are low, or subsidized. It is also clear that education is an important tool in reducing the risk of Arsenicosis diseases in Bangladesh. Improving people's livelihoods is another way to successfully reduce the risk of arsenic-related diseases. Consequently, to effectively reduce the impact of arsenic poisoning, poverty reduction and education should be pursued alongside any specific financial support initiatives.